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EFFECT OF AN ELEVATED TEMPERATURE HIGH HUMIDITY ENVIRONMENT ON --ETC(U)

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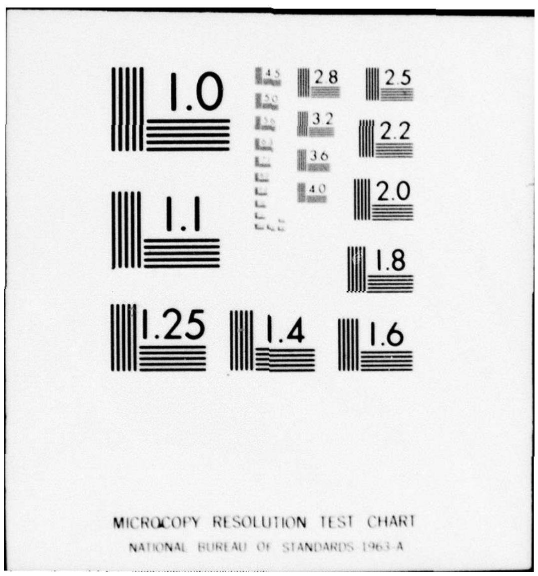
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EFFECT OF AN ELEVATED TEMPERATURE HIGH HUMIDITY ENVIRONMENT ON SCOTCH ~~NO.~~ 425 ALUMINUM TAPE.
Number

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The effect of aging in an elevated temperature, high humidity environment on an aluminum backed pressure sensitive tape has been studied. The tape was bonded to various types of metallic substrates and on some of these substrates a considerable amount of corrosion occurred.

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PREFACE

This report covers work performed during the period from November 1976 to October 1977 under Air Force Contract F33615-76-C-5034, Project Number 7381. The work was administered under the direction of the Materials Support Division of the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio. Mr. Weldon Scardino (AFML/MXE) acted as Project Engineer.

The Principal Investigator on this investigation was William E. Berner. The major portion of the laboratory work was conducted by John Dues, research technician.

This report was submitted by the author in December, 1977. The contractor's report number is UDR-TR-77-77.

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SECTION I
INTRODUCTION

A Scotch No. 425 aluminum tape is of interest for use on steel fuse bodies to seal joints and seams quickly and inexpensively. Its ability to withstand extended exposure to adverse environments however needed to be determined. The objective of this investigation was to investigate the functional durability of this tape material in such environments.

An investigation was consequently conducted to determine the effect of an elevated temperature, high humidity environment on both the integrity of the tape material itself and its ability to adhere to metallic substrates.

SECTION II
APPROACH

All of the environmental agings were conducted at 71°C (160°F) and 75 percent relative humidity (R.H.). The effect of environmental aging upon the integrity of the tape material itself was determined by exposing a piece of tape 2.54 cm wide by 10.16 cm long (1 inch by 4 inches) to the environment and periodically inspecting this tape for observable changes. In addition to the observable qualitative changes occurring during the exposure period, this piece of tape was also used, at the conclusion of the 134-day environmental exposure, to prepare a peel test specimen on a solvent cleaned 6061T6 aluminum panel. The peel strength obtained therefrom provides a quantitative measure of the effect of the environmental exposure upon the tape. The effect of environmental exposure upon the ability of the tape to adhere to the steel substrate was determined with peel tests. The fuse bodies are made of 1024 steel alloy. Since flat panels of this alloy were not readily obtainable within a reasonable length of time, peel specimens were prepared on flat panels of 1018 steel alloy. The principal difference between these two alloys is that the 1018 has a slightly lower carbon content than the 1024. This difference was felt to be of negligible significance in the tests conducted and herein reported.

In addition to the 1018 steel panels, peel specimens were also prepared using 6061T6 aluminum panels. These panels were included in the investigation because it was anticipated that galvanic corrosion might well be a problem on the specimens comprised of the dissimilar aluminum tape and steel substrate panels. As will be seen, this will indeed prove to be the case. As a consequence of this corrosion problem with the 1018 steel alloy substrate, additional peel tests were conducted on some actual 1024 steel alloy cylindrical fuse bodies with four different types of surface plating; cadmium, nickel, tin, and solder. For these latter tests, a special testing technique was devised to simulate the conditions of a flat-panel peel test as nearly as possible. Table 1 lists the various types of peel specimens prepared and tested during this investigation.

TABLE 1

TYPES OF PEEL TEST SPECIMENS

Substrate Alloy	Specimen Type
1018 steel	Flat Panel
6061T6 aluminum	Flat Panel
cadmium plated 1024 steel	Cylindrical Fuse Body
nickel plated 1024 steel	Cylindrical Fuse Body
tin plated 1024 steel	Cylindrical Fuse Body
solder plated 1024 steel	Cylindrical Fuse Body

Peel tests on all of the different types of specimens were conducted on unaged as-fabricated specimens, on specimens which had been aged for 60 days, and on specimens which had been aged for 120 days.

SECTION III

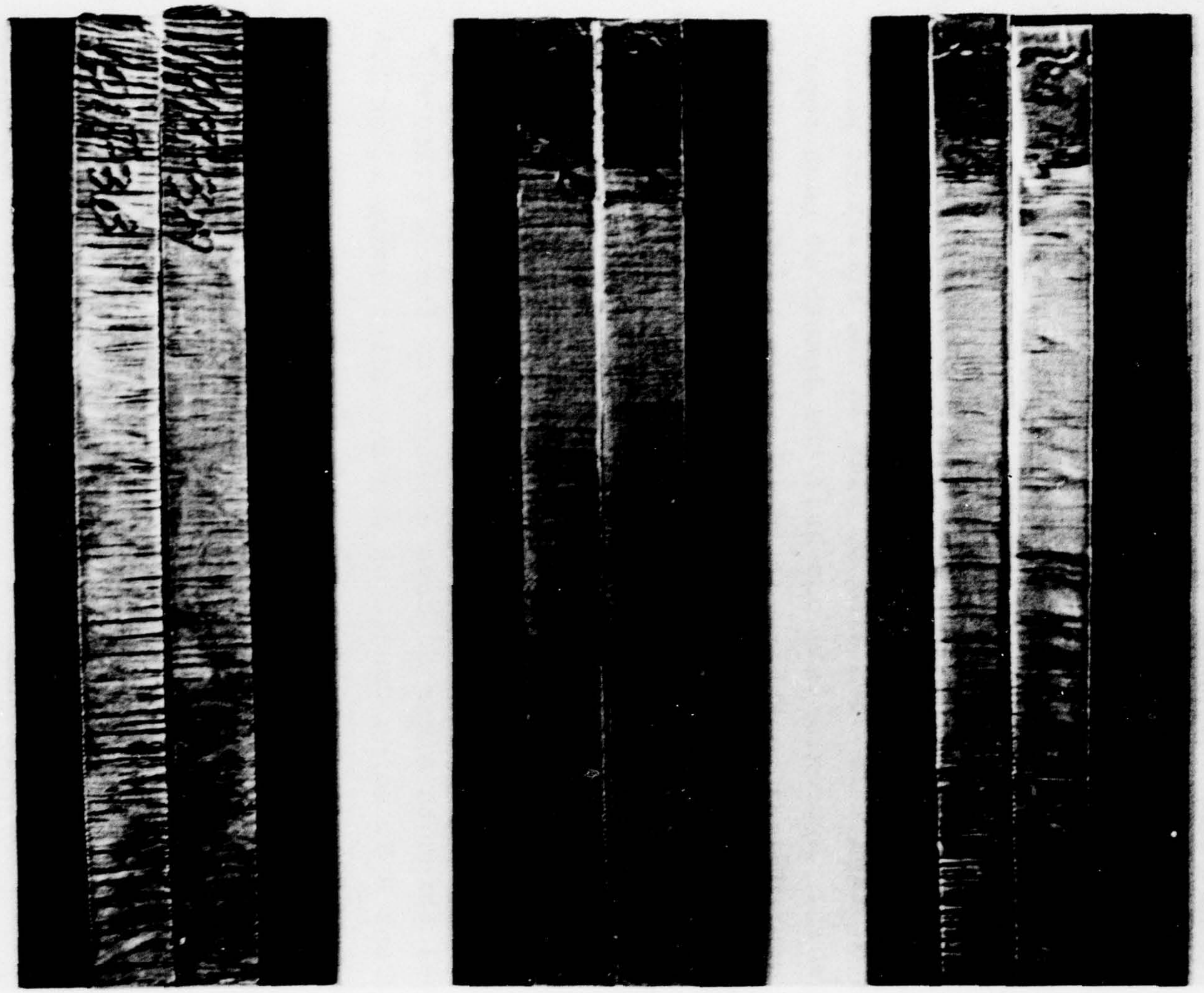
PREPARATION AND TESTING OF PEEL PANELS

The peel specimens were fabricated in accordance with the requirements of Federal Specification L-T-80. For each substrate alloy the surface cleaning procedure, prior to tape application, consisted of: cleaning and scrubbing the surface with hot mineral spirits; wiping dry with a clean towel; an n-heptane rinse using a pipette, and ; a final wipe dry.

On the flat panel peel specimens, each specimen consisted of two 1.27 cm (one-half inch) wide by 25.4 cm (10 inch) long strips of tape laid down side by side on the substrate panel (Figure 1). Approximately one-half the length of each tape strip was adhered to the metallic substrate leaving the remainder free for gripping in subsequent peel tests. A 7.26 cm (3.25 inch) diameter, rubber covered steel roller was utilized to roll the tape onto the panel. Nine such flat panels were prepared using 1018 steel and 6061T6 aluminum. Each of these sets of nine were subdivided into three groups of three panels each. One group was tested without any environmental exposure to establish control peel strength. A second group was tested for peel strength after 60 days exposure to the 71°C(160°F)/ 75 percent R.H. aging condition and the third group after 120 days exposure.

The environmental exposures were conducted by placing the specimens in a closed glass tank with a saturated salt water (NaCl) solution in the bottom. The specimens in this tank were standing on end, supported by a glass rack, with their lower edge approximately 2.54 cm (one inch) above the surface of the solution. The tank was placed in a circulating air oven to maintain temperature.

The preparation of the peel specimens on the cylindrical fuse bodies was somewhat different than on the flat panels. Two fuse bodies of each type surface plating were available.



SCOTCH #425 Alum. Tape on 1018
Steel - No Exposure

Figure 1. Flat Panel Peel Specimens-Two Side-by-Side Tape Strips.

One of these two, for each type surface plate, was used for unaged control peel tests and the other for peel tests after aging for either 60 or 120 days. Adhesive tape strips 1.27 cm (one-half inch) wide by about 50.8 cm (20 inches) long were applied circumferentially around the fuse bodies (three strips on the control and six strips on the body to be aged - see Figure 2). An 8.25 cm (3.25 inch) diameter rubber covered steel roller was used to roll the tape onto the fuse body. The adhered tape extended nearly completely around the fuse body (Figure 2).

The flat panels were tested for peel strength according to the standard peel test procedures described in L-T-80. The cylindrical fuse body specimens were clamped onto the testing machine as illustrated in Figure 3 in order to conduct the peel tests.

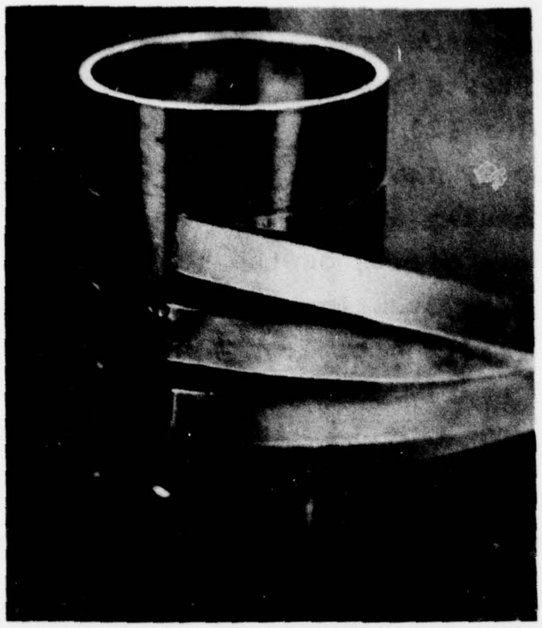
SECTION IV
RESULTS AND DISCUSSION

The adhesive tape which was exposed to the 71°C(160°F)/ 75 percent R.H. environment for 134 days exhibited a sensible softening and loss of tackiness early in the aging period with little subsequent change. Table 2 lists the changes observed with each inspection. After 134 days this strip of tape was

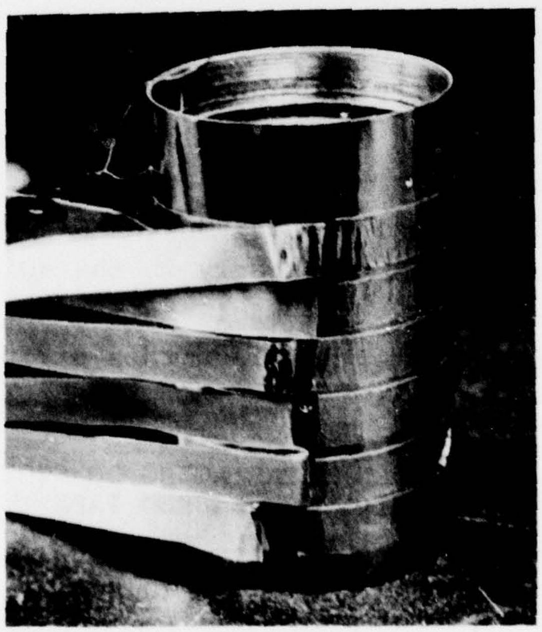
TABLE 2

EFFECT OF ENVIRONMENTAL AGING ON SCOTCH NO. 425 ALUMINUM BACKED TAPE

Time in 71°F(160°F)/ 75% R.H. (days)	Observed Changes
5	adhesive felt mushy
19	lost some tackiness
29	no further change
35	additional loss of tackiness
54	no further change
97	no further change
134	no further change

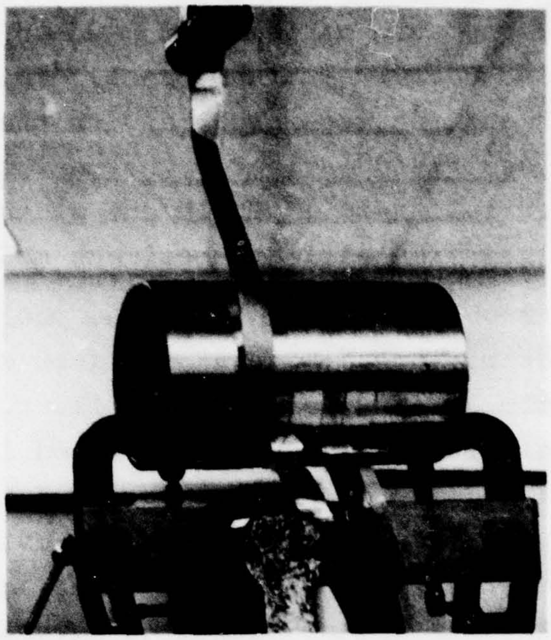


(a) Control Specimen - Three Strips of Tape

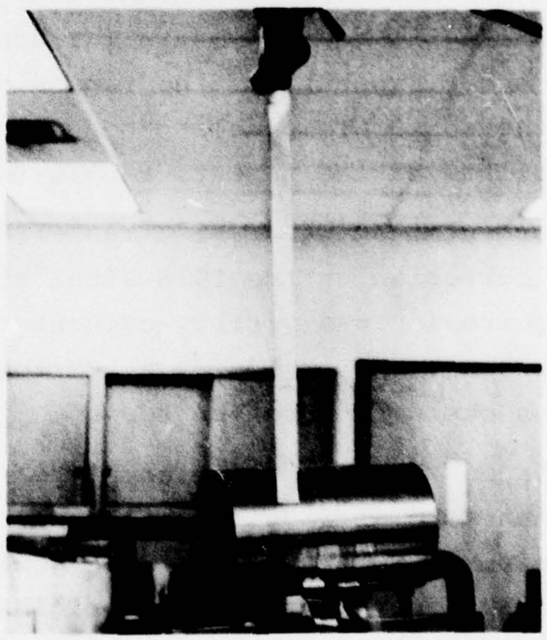


(b) Specimen For Environmental Exposure - Three Strips to Be Tested After 60 Days and Three After 120 Days Exposure

Figure 2. Fuse Body Peel Specimens.



(a) Test Setup Just Prior to Load Application



(b) Test In Progress

Figure 3. Peel Testing of Tape Specimens on Cylindrical Fuse Bodies.

removed from the exposure cabinet and used to prepare a peel specimen on a flat 6061T6 aluminum panel. This panel was cleaned with MEK and the tape applied with the rubber covered steel roller as described earlier. The peel strength of this specimen averaged 1.31 N/cm (0.75 lb/in) width, substantially below that obtained from similar specimens made with unaged tape.

The results obtained for all of the peel tests conducted during this program, including that one just described, are presented in Table 3. Figures 4 and 5 illustrate the appearance of the 1018 steel flat panels and the plated fuse body specimens after the 60 and 120 day aging periods. The 6061T6 aluminum flat panels are not illustrated because no evidence of corrosion damage was present on these specimens after aging. Inspection of Table 3 and Figures 4 and 5 leads to several significant observations.

The 60 and 120 day exposures had no adverse effect on the peel strength of the No. 425 tape on the aluminum substrate. In fact, the peel strength after exposure was nearly double that of unaged specimens. Exposure of the tape alone, however, before application to the substrate panels produces substantial loss ($\pm$30%) in the ability of the tape to adhere to aluminum.

The environmental aging at 71°C(160°F) and 75 percent R.H. produced severe corrosion on the 1018 steel substrate panels. After 60 days, corrosion was visibly evident and peel strength had fallen 10 percent. After 120 days, corrosion was severe and the specimens could not even be tested.

The results on the four different types of plated fuse bodies is somewhat more difficult to interpret. On three types of plating (cadmium, tin, and solder) the peel strength was higher after 60 days aging than on the original unaged specimens, but after 120 days on these three types, the peel strength was either lower than the original or could not be tested due to excessive corrosion of the unbonded tape gripping tabs. On the fourth type of plating (nickel) the peel strength was lower after

TABLE 3

EFFECT OF ENVIRONMENTAL EXPOSURE ON PEEL STRENGTH OF SCOTCH NO. 425 ALUMINUM BACKED TAPE

Substrate Type	No. of Days at 71°C (160°F)/75%RH	Peel Strength[1]	
		(lb/in. width)	(N/cm width)
6061T6 aluminum, flat panel	0	1.18	2.07
	60	2.21	3.87
	120	2.22	3.89
6061T6 aluminum, flat panel	0[2]	0.75[2]	1.32[2]
1018 steel, flat panel	0	1.66	2.91
	60	1.49	2.61
	120	--[3]	--[3]
cadmium plated fuse body	0	1.70	2.98
	60	2.31	4.04
	120	1.59[4]	2.78[4]
nickel plated fuse body	0	1.95	3.41
	60	1.75	3.06
	120	2.37[5]	4.15[5]
tin plated fuse body	0	2.60	4.55
	60	2.61	4.57
	120	1.24[5]	2.17[5]
solder plated fuse body	0	2.07	3.62
	60	3.68	6.44
	120	--[3]	--[3]

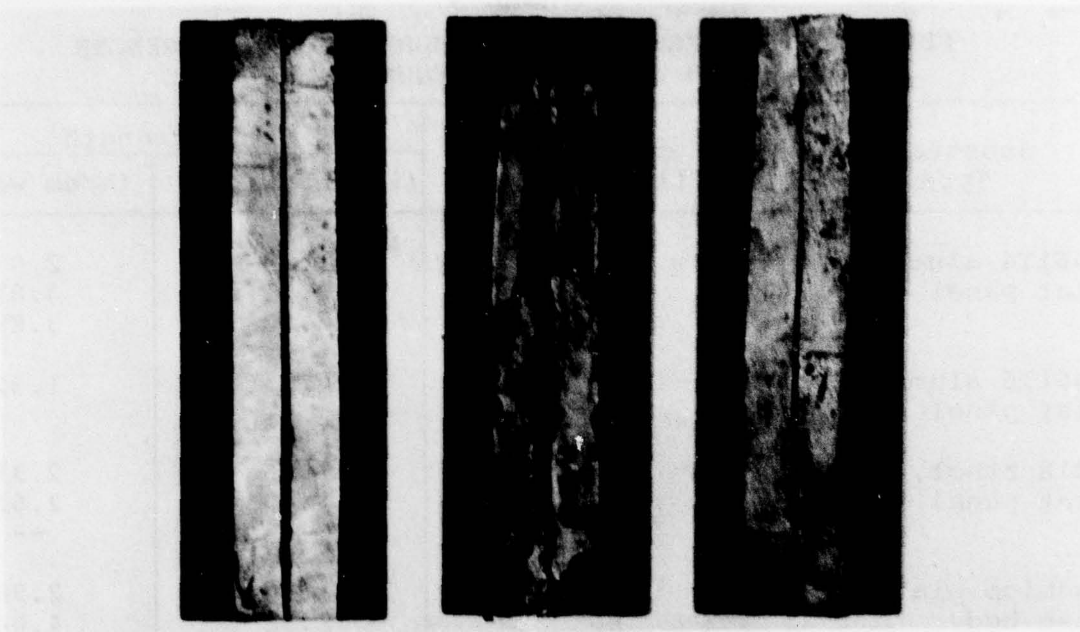
[1] Average of three specimens except where noted. Data for each individual specimen is presented in Appendix 1.

[2] Only one specimen. Made using tape which had been exposed to 71°C (160°F)/75% R.H. for 134 days prior to preparation of peel specimen.

[3] Specimens had corroded too badly to permit testing.

[4] Only one specimen could be tested - other two too corroded.

[5] Only two specimens could be tested - other one too corroded.



(a) 60 days aging

(b) 120 days aging

Figure 4. Appearance of Flat 1018 Steel Peel Panels After Aging at 71°C(160°F) and 75% R.H.

(a) 60 days aging

(b) 120 days aging

Figure 5. Appearance of Plated Fuse Body Specimens After Aging at 71°C(160°F) and 75% R.H.

60 days aging than the original value but after 120 days aging it was higher than the original.

Based on the 120 day peel strength data, the nickel plated and cadmium plated fuse body specimens appear more resistant to degradation in a 71°C(160°F)/75 percent R.H. environment than the tin or solder plated specimens. Another measure of resistance to degradation besides peel strength, however, exists. This is given by the footnotes in Table 3 and indicates the extent of corrosion as it relates to the ability to conduct a test on the aged specimens. As can be seen after 120 days aging, the tin and nickel plated bodies permitted two of the three specimens to be tested, the cadmium plated body permitted one of the three specimens to be tested, and none of the specimens on the solder plated body could be tested. In summary, the nickel plated body appeared to have the best long-term resistance to degradation of the four types tested according to both measures, peel strength, and number of specimens destroyed. It should be noted, however, that if the 60 day data were employed, the nickel plated bodies would rank below the other three types of plating. For this comparison, only peel strength can be used since all three specimens of each type plated fuse body could be tested. Perhaps the most significant result is that regardless of whether the 60 or 120 day results are utilized, all four of the plated fuse bodies exhibit better resistance to degradation than the unplated 1018 steel panels.

It is evident in Figures 4 and 5 that salt deposits are present on the test specimens. A sodium chloride solution was used to obtain the 75 percent R.H. environment, and even though the test specimens were never in direct contact with the liquid solution in the aging tanks, it is obvious that some of the electrolyte did deposit upon the samples. The presence of this corrosive media on the samples no doubt contributed to the corrosion which occurred. Since the aluminum foil tape was galvanically dissimilar to all of the substrates to which it was applied except for the flat 6061T6 aluminum panels, it would seem that galvanic corrosion played a significant role in the aging process. Had the specimens been aged in an environment free of a strong inorganic electrolyte, even if it had been at 100 percent R.H. rather than 75 percent, different results might have been obtained.

SECTION V
CONCLUSIONS AND RECOMMENDATIONS

Based upon the tests conducted, the 6061 aluminum appears to be the best substrate for resistance to corrosive degradation when Scotch No. 425 aluminum tape is bonded to it and the bare 1018 steel is the worst. The four types of plated steel fall between these two extremes, with all four proving better than the bare steel. The relative ranking of these four types of plated steel seems to depend upon the length of the exposure period with solder plating looking best after 60 days but worst after 120 days, while nickel plating looks worst after 60 days but best after 120 days.

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